D2-212 Spectroscopy Module

Spectroscopy Module

Model No. D2-212

Document Revision: 1

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Please read Limited Warranty and General Warnings and Cautions prior to operating the D2-212.

Description

The D2-212 saturated absorption spectroscopy module provides error signals derived from saturated absorption spectroscopy of atomic rubidium, cesium, or potassium. It contains a vapor cell, internal temperature controller, balanced photodetectors, and optics. Temperature control stabilizes the number density of atoms in the cell.The photodiode output is shot-noise limited out to greater than 5 MHz for photocurrents of 100 µA and above. The high bandwidth of the feedback enables tight solid locking that is immune to vibrations and shock. The D2-212 is powered by a cable that plugs into the power connectors on any D2 series electronics module or into an ICE-PB1 board, depending on which system you purchased.

Absolute Maximum Ratings

Note: All modules designed to be operated in laboratory environment.

Parameter	**Rating**
Environmental Temperature	>15°C and <30°C
Environmental Humidity	<60%
Environmental Dew Points	<15°C

Specifications

	Value	**Units**
Input Light Level	0.25 < P < 100	mW
Photodiode Amplifier		
<html> </html> Transimpedance (signal)	20,000	Ω
<html> </html>Bandwidth (signal)	5	MHz
<html> </html>Output Impedance	50	Ω
<html> </html>Noise @ 5 MHz	<23	nV / <HTML> √Hz</HTML>
Set Temperature	15 to 75	°C
Temperature Stability	<0.1	°C
Beam Height	0.95	inches
Total package Size (L x W x H)	3.05 x 3.10 x 1.64	inches

Electrical Specifications

	Min	**Typical**	**Max**	**Units**
Input Voltage Range				
<html> </html>+5V	4.5	-	5.5	V
<html> </html>+15V	13.5	-	16	V
<html> </html>-15V	-13.5	-	-16	V
+5V Current Consumption				
<html> </html>Temperature Setpoint = 30°C	-	0.23	1.3	A
<html> </html>Temperature Setpoint = 40°C	-	0.43	1.3	A
<html> </html>Temperature Setpoint = 60°C	-	0.75	1.3	A
Note: Taken with ambient temperature of 23°C in laboratory conditions. Different conditions will result in different current consumption for the 5V rail (the 15V rails are independent of temperature setpoint.				
+15V Current Consuption	-	30	100	mA
-15V Current Consuption	-	20	100	mA
Photodiode Amplifier Output Current	-	-	60	mA

Theory of Operation

Input light passes through an adjustable λ/2 waveplate and polarizing beamsplitter (PBS) that directs a user-controlled portion of the beam to the vapor cell. The beam is then reflected back through the vapor in a counter-propagating configuration and back to the PBS where it is directed onto the photodetector.

The beam diameters were designed to provide enough photocurrent (~50-100µA) to give shot-noise-limited performance out to 5 MHz while limiting saturation broadening. For Vescent's D2-100-DBR lasers, the bandwidth is useful to provide for tight and stable locking by feedback to injection current.

The vapor cell is temperature controlled with two Thermoelectric Cooler (TEC) units configured in a master/slave configuration. The master TEC controls the vapor pressure in the cell while the slave TEC controls the temperature of the windows on the cell. To prevent condensation of the Alkali metal on the window, the windows on the cell are set to a higher temperature relative to the master TEC. The slave TEC always tracks the master temperature setpoint and maintains a fixed offset from it. The temperature setpoint of the master and the slave offset can be changed using trimpots located inside the device.

Inputs, Outputs, and Controls

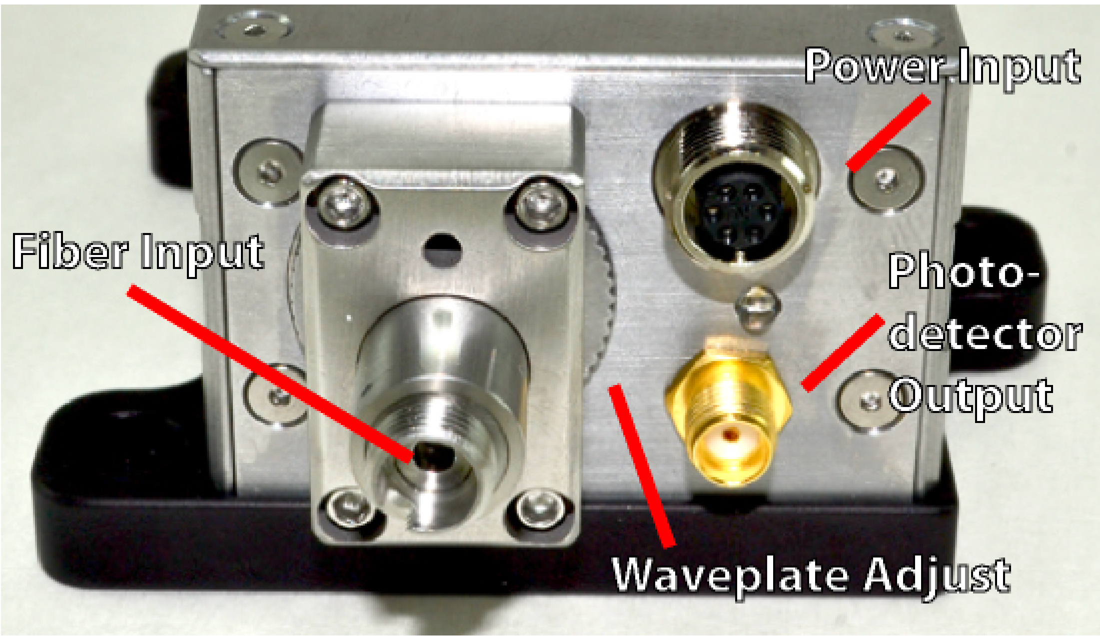

Fig. 1

Input Connector (6-pin circular)

Power from the D2-series power bus or other power supply are made through a 6-pin circular connector (Hirose HR10A-7R-6SB) shown in figure 1. The pin definitions (pin numbers are marked on the connectors) are listed below.

Pin	Input Voltage	Max Current Draw	Notes

Pin	Input Voltage	Max Current Draw	Notes
1	+5V	1.5A	
2	No Connect		
3	+5V Ground		Return path for high current +5V.
4	Signal Ground		Return path for voltages on pins 5 & 6.
5	-15 V	100mA	See note below.
6	+15V	100mA	See note below.

Note: See D2-005 manual for pin out on D-Sub 9-pin connector.

Signal Output (SMA)

The photodiode signal is output through an SMA connector below the power connector shown in figure 1. Connect to ERROR INPUT on the Laser Servo. The output of the photodetector circuitry is designed to drive signal into a 50Ω terminated load. The drive strength of this output allows a maximum DC output voltage of 5V. Applying too much light to the module such that the output DC level exceeds 5V will cause saturation of the circuitry. It is recommended to adjust the input light power using the λ/2 waveplate attenuator such that the maximum DC level on the this output is about 3V or less.

Temperature Setpoint Adjustment

The master TEC setpoint which controls the vapor pressure of the cell is controlled by the trimpot labeled “Temp Set” in figure 3. Adjusting this trimpot will set the master TEC operating temperature. The slave TEC, which heats the vapor cell's windows will track changes to the master's setpoint, remaining at the offset set by the Window Offset Adj trimpot described below.

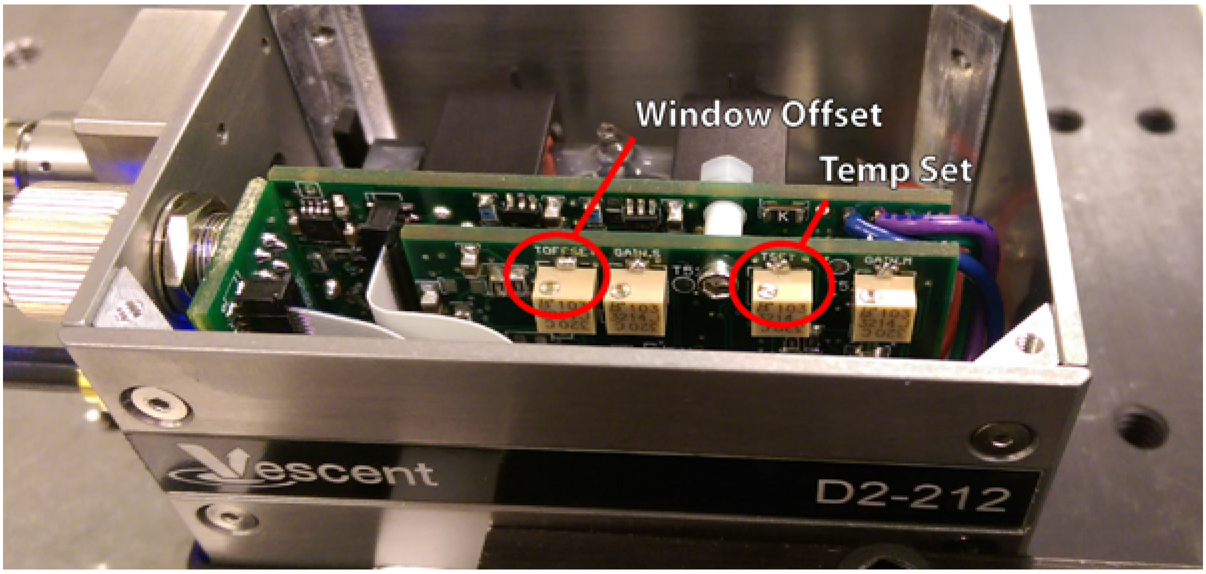

Fig. 3: Locations of temperature setpoint and offset trimpots.

Fig. 4: Locations to probe with voltmeter while settings while adjusting trimpots.

The extent of the trim range can be determined by probing the location shown in figure 4 with a voltmeter referenced to case ground (the outer shell of the SMA connector is a good reference point). Probing this location gives the wiper voltage of the trimpot which corresponds to temperature as shown in the table below. This 10-turn trim pot sets temperature from 15°C (fully CCW) to 75°C (10 turns CW). The 5-turn point is approximately 42°C. The following table gives approximate temperature settings for the three available alkali options:

Alkali	Turns CW	Wiper Voltage	Temp
cesium	2	6.8V	~30°C
rubidium	4-5	5.7V	~40°C
potassium	8-9	3.9V	~60°C

Window Offset Adjustment

This trimpot labeled in figure 3 as “Window Offset” sets the operating temperature offset of the slave TEC relative to the master TEC setpoint (set by Temperature Setpoint Adjustment, described above). The slave TEC controls the temperature of the vapor cell's windows. If the trimpot is turned fully CCW, then there will be zero offset and the slave TEC (and the vapor cell windows) will be at the same temperature as the master TEC. In practice, this is usually undesirable as the Alkali metal in the cell can condense on the windows and block transmission. Usually, the slave TEC should be set to a higher temperature than the master to prevent condensation on the windows. Adjusting the trimpot to a value CW increases the offset of the slave TEC temperature setpoint relative the to setpoint of the master TEC. This offset will always be to a higher temperature relative to the master. This temperature offset will track changes to the master TEC's setpoint, so the offset will not need to be changed if the master TEC's temperature setpoint is changed later on.

Master Proportional Gain Adjustment

This trimpot is located to the right of the “Temp Set” trimpot shown in figure 3. This controls the proportional gain of the master TEC's PID control loop. It is factory set for loop stability, but it may be adjusted if there are stability issues. Turning this CW increases gain, while CCW decreases gain. It's setpoint may be recorded by using an Ohm-meter to measure the resistance from the trimpot's wiper lug (similiar to the probe points shown in figure 4 to case ground while the D2-212 module is unpowered. The factory setting is generally about 2kΩ to ground.

Slave Proportional Gain Adjustment

This trimpot is located to the right of the “Window Offset” trimpot shown in figure 3. This controls the proportional gain of the slave TEC's PID control loop. It is factory set for loop stability, but it may be adjusted if there are stability issues. Turning this CW increases gain, while CCW decreases gain. It's setpoint may be recorded by using an Ohm-meter to measure the resistance from the trimpot's wiper lug (similiar to the probe points shown in figure 4 to case ground while the D2-212 module is unpowered. The factory setting is generally about 2kΩ to ground.

λ/2 Waveplate

A waveplate attached to the front plate by magnets (shown in figure 1) can be used to attenuate incoming light by rotating the knurled ring. Once set, the waveplate can be locked in place using the set screw accessed in the small hole above the fiber input.

Quick Setup Guide

1. Connect the provided SMA to BNC cable from the SMA output on the D2-212 to the Error In input on the Peak Lock servo.
2. Connect power to the module using the provided Hirose to DB9 power cable.
3. Connect the fiber cable to the module.
4. Wait for the module to temperature stabilize. It is stabilized when the blue LED between the power connector and SMA output illuminates. This should take less than a few minutes.
5. View the output of the servo Error Input monitor on an oscilloscope in DC coupled mode.
6. Turn on the laser and ensure it isn't on transition. We are going to ensure the photodetector in the D2-212 isn't saturated by checking its DC level on the oscilloscope.
7. Adjust the λ/2 waveplate on the front of the D2-212 to attenuate the input signal until the DC level on the scope of the Error Input monitor is below 3V. If the DC level is higher than this, the photodetector circuitry may saturated and show erratic behavior.
8. The module should now be set up for spectroscopy.

Troubleshooting

Rubidium on Vapor Cell Windows

TBD

Polarization Sensitivity

TBD

Performance

Below, figure 5 is a scope trace representative of spectroscopy for ^{87}Rb. The yellow trace is taken from the Error Input monitor of the servo. The green trace is the derivative of the yellow sweep. The two hyperfine transitions are marked with vertical cursors.

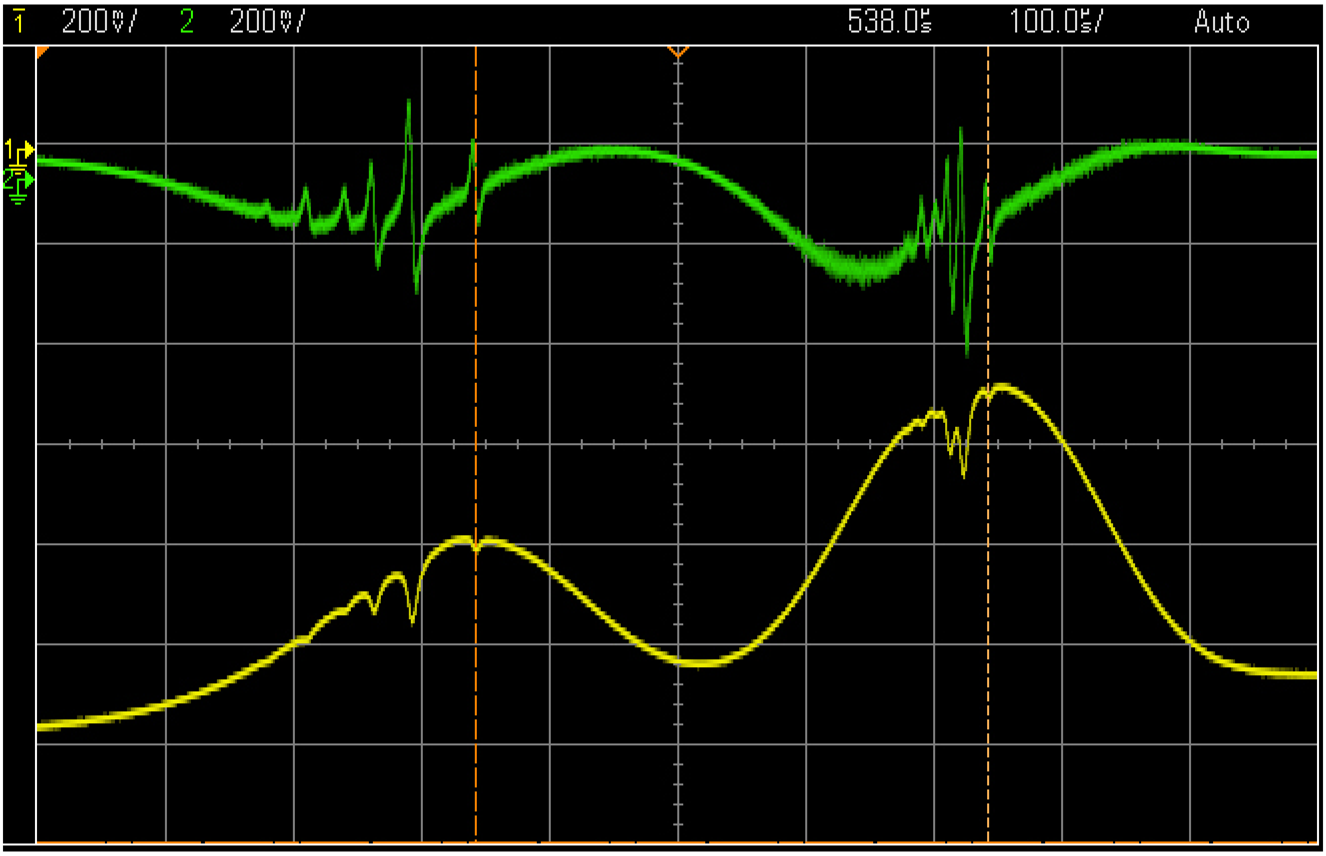

Fig. 5: Example of spectroscopy signal.

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